MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

EOP4066 – OPTICAL COMMUNICATION SYSTEMS

(All sections/Groups)

15 OCTOBER 2019
9:00 a.m. – 11:00 a.m.
(2 hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 6 pages (including the cover page) with 4 questions only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the answer booklet provided.

Question 1 (25 marks)

(a) An optical communication system transmits optical signals using optical fibers.

(i) Illustrate and label accordingly an optical communication system with all the main optical components. [3 marks]

(ii) Laser diodes and light emitting diodes (LEDs) are two types of optical transmitter. Which optical transmitter is suitable to be used in a local network? Give THREE (3) reasons to support your answer. [5 marks]

(iii) Avalanche photodiode is widely used in an optical communication system. Is this statement true? Give TWO (2) reasons to support your answer. [4 marks]

(iv) Describe TWO (2) differences between a semiconductor laser amplifier and a fiber amplifier. [4 marks]

(b) The photocurrent of a photodiode is measured as 1.8 μA. The post detection bandwidth is 22 MHz. Determine the signal-to-noise ratio (SNR) in dB when the photocurrent is the signal. Assume that there is no noise due to dark current. [5 marks]

(c) With an input power of 3 dBm, the output power of an Erbium doped fiber amplifier (EDFA) has increased to 30 dBm. Determine the amplifier gain and the minimum pump power required if the amplifier is operating at 1550 nm and the pump wavelength is 980 nm. [4 marks]

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Question 2 (25 marks)

(a) A silica optical fiber link with a length of 5 km uses a light emitting diode (LED) which launches a mean optical power of 0.2 mW into a multimode fiber. The LED and its drive circuit has a rise time of 12 ns and a material-dispersion-related-rise time degradation of 20 ns over the 5 km length link. There is a connector loss at the transmitter of 1 dB.

The fiber has a loss of 2.5 dB/km with splice losses of 0.5 dB/km. The fiber also has a 400-MHz. km bandwidth-distance product with a q = 0.7 and a material dispersion parameter of 100 ps nm^{-1} km^{-1} at a wavelength of 850 nm.

There is a connector loss at the receiver of 1 dB. The receiver is a *pin* photodiode with a sensitivity of - 33 dBm and a bandwidth of 30 MHz with a rise-time degradation of 15 ns. A safety margin of 6 dB is required in the system. Assuming that the data stream is using non-return-to-zero (NRZ), the maximum allowable rise time degradation is 30 ns.

(i) Does the system fulfill the power budget requirement? Justify your answer with an optical power budget calculation. [4 marks]

(ii) Does the choice of components meet the system design criteria? Justify your answer with a system rise time calculation. [4 marks]

(iii) If a laser source with a mean power of 1 mW is used in the system and the safety margin is increased to 8 dB, is there any increase in the fiber link length? Justify your answer with an optical power budget calculation and the new fiber link length. Assume that the losses due to fiber attenuation, splice and connector remain the same as Question 2 (a)(i). [5 marks]

(iv) If the LED in Question 2(a) has a spectral width of 50 nm and transmits at a wavelength of 850 nm, what is the total pulse broadening in the system due to material dispersion? [2 marks]

(v) If the laser in Question 2 (a)(iii) has a spectral width of 5 nm and transmits at a wavelength of 850 nm, what is the total pulse broadening in the system due to material dispersion? Comment on your answer by comparing with your answer in Question 2 (a)(iv). [4 marks]

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Question 2 (Continued)

(b) Scattering may cause attenuation loss in an optical communication system.

(i) Briefly describe TWO (2) types of linear scattering losses. [4 marks]

(ii) Propose ONE (1) method to reduce nonlinear scattering loss. [2 marks]

Question 3 (25 marks)

(a) A linear bus topology is one type of optical fiber network topology.

(i) An optical fiber network with 10 stations (1 km apart) implements a linear bus topology. The fiber attenuation is 0.4 dB/km at 1300 nm. There is a 1 dB connector loss at the source and receiver. Table Q3 shows the losses in the network.

Table Q3: Losses in an optical fiber network

Coupling/loss factor	Loss (dB)
Intrinsic loss	0.5
Connecting loss	1
Coupling tap loss	9
Throughput coupling loss	0.8

Determine the power loss between stations 1 and 10. [4 marks]

(ii) If the number of stations in Question 3(a)(i) is increased to 30 stations and the distance between each station is reduced to 0.5 km, what is the total loss in the network? Comment on your answer. [5 marks]

(iii) Illustrate and describe TWO (2) other types of network topology. [6 marks]

(b) Describe how a broadcast and select network works in a system with 4 end users and a 4-way combiner. Support your answer with a suitable diagram. [6 marks]

(c) Compare how network connections are being set up in wavelength routed networks and wavelength switched networks. [4 marks]

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Question 4 (25 marks)

(a) Wavelength division multiplexing (WDM) is a type of multiplexing scheme to improve the transmission capacity of an optical communication network.

(i) Define the term multiplexing. [2 marks]

(ii) Briefly describe a typical optical channel in a WDM system. [2 marks]

(iii) Evaluate TWO (2) requirements for a laser source used in a WDM network. [4 marks]

(iv) How can dispersion effects in a WDM system be controlled? [3 marks]

(v) Describe THREE (3) methods to reduce the effect of stimulated Brillouin scattering in a WDM system. [6 marks]

(b) A 30 x 30 fiber star coupler is used in a WDM system as a multiplexer. The coupler has 0 dBm of optical power launched into a single input port. Each output port has an ouput power of -18.5 dBm. Determine the total loss (splitting loss and excess loss) incurred by the star coupler. [4 marks]

(c) Linear optical systems introduce loss and dispersion to the optical transmission pulses. Describe TWO (2) ways to minimize these effects. [4 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

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